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A PROPOSED METHOD FOR THE PRESERVATION OF TIMBER.

By F. A. KUMMER, Jun. Am. Soc. C. E.

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WITH DISCUSSION.

In presenting these notes upon a proposed method for the treatment of timber to preserve it from decay, the writer fully realizes that they may seem to add but little to the mass of information already collected upon that important subject; but the experiments which are herein described and the direction in which they lead, indicate a line of improvement in the preservation of timber which will prove of interest.

So many figures have already been presented, proving the great need of a successful method of timber preservation and the immense value of such a process—could one be secured, giving practical results at a reasonable cost—that the means by which this result may be obtained may be at once considered without stopping to prove its necessity.

The experiments herein described, and the lines upon which the proposed process has been developed, were made, particularly with a

view of improving what is at present known as the creosoting process, it being believed that this process would command a much more extensive use if certain mechanical difficulties, now met with in connection with its application to timber, and particularly to railroad ties, could be removed. The improvement of this process was also attempted because of its acknowledged merit when properly applied. As at present applied, it possesses certain features which preclude its extensive use in the treatment of railroad ties. If, by a simplification or improvement of the process as now used, the objections hitherto raised to it may be overcome without sacrificing any of the advantages which it possesses, and if, further, this can be accomplished at no greater cost, the resulting process would commend itself to engineers generally.

The often-quoted report* of the Committee of this Society, presented in 1885, said in part:

"If the exposure is to be that of a railroad tie, creosoting is doubtless the most perfect process to use; but in view of the expense, it may be preferable to use a cheaper process, dependent somewhat upon the location."

It is probable that at the present time a greater expense for treatment would be warranted by the cost of timber, as well as by the general conditions of roadbed maintenance, particularly upon eastern roads. Without here entering upon a discussion of the expense for preservation which would be justified under given conditions, it would perhaps be better to discuss first the proposed process from a technical standpoint, and, after arriving at its cost, determine to what extent a process of a given cost per tie could be used.

The creosoting process as at present applied in one of the largest, if not the largest, creosoting works in the world, is described in part as follows in the printed publications of that company:

"The Bethel process, the first to use dead oil of coal-tar, consisted of drying the timber naturally, then applying cold vacuum. This takes too long a time, as large timbers, to dry in this manner, take from 3 to 6 months. Consumers of creosoted timber in this country cannot wait for timber to dry naturally, and so steam heat was introduced * * * to hasten the process. By the use of steam, assisted by superheating, the process is reduced to a small fraction of time. By our process timber can be used fresh from the stump or water, and in a few hours the sap and moisture extracted by means of our

* *Transactions*, Am. Soc. C. E., Vol. xiv, page 290.

immense steam boilers and coils, also by our powerful vacuum pumps, and be prepared for impregnating with oil. * * *

"The timber is first loaded on cars and run into the cylinders which are then hermetically sealed with immense iron heads. Steam is then admitted into the cylinder and surrounding the timber, superheated steam is also introduced into the cylinders by means of large coils so that it does not come in contact with the timber, and the heat is maintained until the timber is heated all through at a low temperature so as not to injure the woody fibers. The cylinder is then freed of all vapors, and the vacuum pumps are put to work to exhaust all the sap and moisture, which is then in the shape of vapor, from the cylinder. Heat is maintained in the coils to prevent the vapor from condensing and thereby remaining in the timber. As the vacuum pumps are constantly removing the hot vapor from the timber it is absolutely necessary to keep the heat above the condensing point. To do this requires practical experience and means of knowing what such heat is, and, as said before, these two parts of the process are the most important, and, if properly done, the oil will be readily forced into the timber. After this has been done the oil is admitted into the cylinders while they are under vacuum, and when all the air has been withdrawn they are subjected to pressure until the requisite amount (which is determined by correct gauges and thermometers) has been forced into the timber, which, if the timber has been properly prepared, is only a small part of the process; but if this has not been well done, the oil cannot be put into the timber. The cells of healthy timber are full of different substances, which, when subjected to heat, can be changed into vapor, and unless the vapor has been completely removed you cannot force the oil into the timber, no matter how long the pressure is applied. It is only by practical knowledge and delicate instruments that we determine when the heat has reached the center of the timber, and the vapor there formed has been removed.

"There will be no decay in any part of the timber that has been permeated with the oil, but to have all parts saturated is expensive and useless; for, after the timber has been thoroughly treated by the heat and vacuum process it will last a long time without any oil, and if the crevices and pores are sealed up with the oil to a sufficient depth the timber is as good as if the whole part had been thoroughly permeated with the oil. The quantity of oil to be used should be determined by the use to which the timber is to be subjected."

Before making any comments upon the process just described, the writer will give the reasons for the decay of timber, and state exactly what steps should be taken to prevent this decay. Having done this, he will analyze the dead oil of coal-tar process as at present used, and see whether these necessary steps are carried out properly.

There are two causes for the decay of timber. *First*, through the fermentation of its contained sap, such fermentation being caused by the germs contained or developed in the sap. *Second*, through the introduction of germs of decay from without, through the action of air or water. As Mr. Curtis says:*

"Ties perish by mechanical destruction of the fibers under the rail; splitting by seasoning and cutting out of fiber by respiking; and by natural decay. In its normal condition, to resist these three influences, a timber is required which shall have sufficient hardness to resist the mechanical injury, a high degree of coherence between fibers, and a sap of such a chemical composition as will offer the least encouragement to the development of the fungoid life which destroys the fiber."

To treat a tie satisfactorily, it must first be sterilized throughout; removing at the same time as much of the contained moisture as is possible without injury to the fiber of the wood. Fermentation cannot then take place from within. It must then be treated in such a manner that germs of decay cannot enter from without, or, if they do enter, that the conditions for their development are highly unfavorable. It must further be provided that the antiseptic injected will not be dissipated through any agency, and, if the timber is to be subjected to the crushing effect of heavy railroad traffic, it must in some way be provided that the timber so protected will be able to resist the weights which will pass over it, without excessive crushing.

If a tie be subjected throughout to a sterilizing temperature of 212°, the agencies of fermentation or decay existing in the sap will be killed, and, if prevented from again entering the timber from without, decay cannot take place. This leads to the first important conclusion; namely, that complete sterilization throughout is a necessity in the treatment of timber. Without such sterilization no form of treatment can be satisfactory unless the timber be completely impregnated throughout its entire mass with an antiseptic material, which is rarely if ever accomplished with large timber. Such sterilization means fully 212° at the heart of the stick. Wood is a poor conductor of heat, and, to secure 212° or more at the heart, two ways are open: *First*, long exposure to a temperature of say 215 to 225° Fahr., which is expensive because of the time consumed; *second*, exposure to a temperature of 290 to 300° Fahr., which, under ordinary conditions, will

* *Transactions*, Am. Soc. C. E., Vol. xlii, p. 288.

injure the fiber of the wood, or at least induce extensive splitting or cracking. The necessity for sterilizing is not brought out in the description of the creosoting process previously given, and it seems to be a point, the vital nature of which is not generally recognized. Experiments made upon yellow pine ties, 6 ins. x 8 ins. x 8½ ft., having self-registering thermometers imbedded at the heart by means of an auger hole, 24 ins. deep, bored from the end, showed that with a temperature of 230° Fahr. in the cylinder, and at the surface of the tie, 178° Fahr. was secured at the center in two hours, while with 290° Fahr. at the outside, 249° Fahr. was secured in two hours. Starting with sterilization as an absolute necessity, it is evident that, if such a temperature as 290° can be used without injury to the timber, complete sterilization will be effected, and in a reasonably short time. It would be well to state here that, with a few exceptions, the experiments were made on long-leaf yellow pine of the best merchantable grade, the exceptions being several experiments upon white oak timber, which showed that it is not capable of treatment by such a process, owing to its great tendency to split and crack under high temperatures.

The method adopted to render the use of such high temperatures possible in the treatment of yellow pine is the application of pressure simultaneously with the application of heat. When the doors are closed the heat is raised to 215° Fahr. without pressure, taking one hour to accomplish this, and kept for one hour at 215° without pressure. This is for the purpose of getting rid of the moisture. Then the heat is increased, pressure is applied, and both are raised gradually, to avoid injury to the fiber, for two hours, until the heat has reached about 285° and the pressure about 90 lbs., and both are held there for one hour. The heat is then shut off, and the tanks are allowed to cool gradually for one hour. At the end of this time the heat is reduced to 250° and the pressure to about 40 lbs. The pressure is then blown off and the heat still further reduced. Vacuum is then applied until about 26 ins. is reached, and while under vacuum the mixture is run into the cylinder at a temperature of 175 to 200° and hydraulic pressure applied reaching 200 lbs. per square inch, and kept at this point until the desired amount of the mixture is absorbed. The liquid is then run off, and the wood is placed in another cylinder, and milk of lime, at a temperature of about 150°, is run in, and hydraulic

pressure of about 200 lbs. is applied for from one-half to one hour. The following is a condensed table of the treatment:

1 hour to reach	215°	Fahr.
1 hour under	215	"
2 hours (heat and pressure applied gradually) to reach	285	"
1 hour (90 lbs. pressure) at	285	"

1 hour cooling.

1 hour vacuum (26 ins.).

½ hour filling cylinders with mixture.

3 hours pressure (average 8 to 10 lbs. absorption).

½ hour emptying tanks.

1 hour under lime and pressure treatment.

The time will be increased or decreased, in keeping with the amount of absorption required.

After the preliminary treatment, the temperature of the interior of the cylinder is raised to 285 or 290° Fahr. If this temperature were maintained at atmospheric pressure, not only would the sudden and rapid evaporation of the remaining moisture in the stick induce splitting and cracking, but the volatile oils in the wood would be driven off, and this is not desirable, inasmuch as they play a not unimportant part in the preservation of the timber. Air pressure is therefore maintained in the closed cylinder at about 80 to 90 lbs. per square inch, so that while the tie is sterilized by heat, the natural oils are not driven off, and splitting and cracking does not result, while the heat is at the maximum.

One of the benefits of the vacuum is to exhaust the air which was forced in while the wood was under pressure, and which, if not removed, would have to find its way out subsequently either through the mixture or by creating cracks.

Mr. J. W. Putnam, in a letter to Octave Chanute, M. Am. Soc. C. E., Chairman of the Committee on the Preservation of Timber, in 1885, wrote as follows:*

"The most carefully conducted experiments indicate that there is no decay without fermentation, and no fermentation without germs. If a piece of timber be cut green and thoroughly coated with paint, it will soon be destroyed by what is called dry rot. If a similar piece be heated through to 225° Fahr., and a sufficient amount of oil be forced

* *Transactions*, Am. Soc. C. E., Vol. xiv, 1885, p. 337.

in to form an impervious coating, no decay will take place until that coating is broken."

This not only evidences the necessity of complete and thorough sterilization, but brings us to the next step in the process, the impregnation of the timber with the antiseptic material. Having thoroughly sterilized the tie, the natural continuance of the process is, of course, the application of the vacuum, to remove from the pores of the timber the air or vapor which they contain and admit the preservative fluid under this vacuum.

The preservative fluid used is not creosote, or dead oil of tar alone, but consists of dead oil of coal-tar, 38%; formaldehyde, 2%; and melted resin, 60%, by weight. The specific gravity of the resulting mixture at 300° Fahr. is 1.068. The resin is used to render the mixture absolutely waterproof, the formaldehyde to strengthen the antiseptic nature of the compound, necessarily somewhat reduced by the reduction in percentage of the dead oil itself. Upon this point the following extracts* from a letter by Mr. Edward R. Andrews to Mr. Chanute will be of interest:

"Creosote oil is a distillate of coal tar—a residual product in the manufacture of coal gas. Chemists have procured from coal tar a vast number of sub-products and combinations of great usefulness in dyeing, etc. The three principal coarse products of coal tar are the light oils, the heavy oils and pitch, all the results of distillation.

"The light oils (lighter than water) evolve in the distillation at a temperature of 360 to 480° Fahr. From these all the aniline colors are made. They are expensive and have no value whatever in wood preservation. The heavy oils (heavier than water) are distilled at a temperature of from 480 to 760° Fahr. These are the so-called creosote oils, and contain all the constituents of the coal tar useful in wood preservation. After the creosote comes the pitch. Creosote contains about 5% of tar acids, *i. e.*, carbolic, cresylic and other acids, but the bulk is made up of semi-solid oils and naphthaline.

"Wood preservation by the metallic salt processes is solely chemical. Earlier, it was claimed that the zinc chloride, etc., formed insoluble chemical combinations with the albumen contained in the sap wood. Now, it s generally allowed that no such combinations are formed, but that the value of metallic salts as antiseptics depends upon their continual presence in the woods, and as they are readily dissolved out of the wood their effect is only temporary. The life of wood is prolonged by their use, when skillfully applied, yet in moist places they quickly lose their efficacy.

* *Transactions*, Am. Soc. C. E., Vol. xiv, Appendix No. 14, p. 341.

"The creosoting process is both chemical and mechanical. Besides the carbolic and other acids, it contains many other well-recognized antiseptic constituents; but it is probable that the very long life of timber secured by thorough creosoting is due far more to the fact that the pores of the wood are filled up with the thick, gummy, insoluble oils and naphthaline, and thus keep out air and water, which contain the germs of decay. That such is the case was conclusively shown by M. Roltier, a Belgian chemist, and later, in 1866, by M. Charles Coisne, Chief of Section of the State Railways of Belgium, and Superintendent of the Creosoting Works.

"By the latter, two series of experiments were tried, during a period of five or six years, in burying in a compost heap made of decaying wood, manure, etc., shavings impregnated with creosotes containing different percentages of carbolic acid. The results showed that shavings saturated with carbolic acid alone were entirely decayed, and those saturated with the distillates at the highest temperatures which contained no carbolic acid whatever were perfectly sound.

"Experience with the metallic salts and the results of above experiments indicate that to preserve timber something more is required than an antiseptic for the purpose of coagulating the albumen. The very small percentage of albumen contained in the sap wood probably ferments readily and may originate decay; but the agencies of fermentation introduced into exposed timber by the air and water absorbed by the wood are vastly more dangerous than the seeds of decay contained originally in the wood itself.

"During the past hundred years almost every imaginable substance has been proposed as a preservative of wood, yet it may be that inventors are still at work, if so, their attention would be best directed to such methods or materials as would close the pores of wood to air and water."

This would indicate that creosote is more valuable because of its function in filling the pores of the wood and excluding air or moisture containing germs of decay than because of its direct antiseptic action. To a considerable extent, this is doubtless true, but the writer thinks that the ideal preservative should be both antiseptic and waterproof, and should possess the latter characteristic in the highest obtainable degree. To secure such a material was the chief object of the experiments which resulted in the process herein described, and the compound finally fixed upon consists of approximately 38% by weight of dead oil of coal-tar, 60% of melted resin and 2% of formaldehyde. The idea of introducing the resin was to obtain a substance in the highest degree waterproof, and there are few substances known more highly waterproof than pine resin.

This mixture is perfectly fluid at 200° Fahr., and, by some peculiar action not readily explainable, seems to be more readily forced into the wood than the creosote oil alone. There are a number of very important advantages gained by the use of the resin in connection with the dead oil. Timber treated by the ordinary creosoting process is more or less spongy and soft, and while the dead oil is not generally regarded as soluble, it is still subject to dissipation by the action of water, as is well known in the case of treated piles subject to the washing action of salt water. Experiments made by immersing in water timber untreated and treated by the process just described, showed results as follows:

One piece creo-resin timber, 6 ins. x 8 ins. x 8 ft., immersed in water 27 days, absorption 1¾ lbs. One piece, same stick as above, untreated, absorption 11¼ lbs. The increase in weight of the first stick was largely due to water clinging to the surface.

Timber treated with dead oil in conjunction with resin is practically absolutely waterproof and very much harder than the untreated timber, instead of being softer and more spongy, as is the case with creosoting proper. The introduction of bacteria from without should be prevented by a process as highly waterproof as it is possible to make it, and this process should use a material which will not only have these waterproof qualities, but will be so antiseptic in nature that the possibility of the existence or development of decay germs, if such germs by any means gain an entrance into the timber, should be reduced to a minimum. In fact, the conditions should be such as to absolutely preclude any possibility of their life or development. To secure these results, the combination of resin, creosote oil and formaldehyde is especially well adapted. The material weighs about 8.9 lbs. per gallon.

TABLE No. 1.

No.		Maximum Heat.	Pressure, in Lbs.	Pounds per cubic foot.
13 C.	Green.	285°	90	3.33
13 C.	Vulcanized.	285°	90	6.5
16	Green.	275°	80	7.14
16	Vulcanized.	275°	80	10.66
17	Green.	285°	85	3.43
17	Vulcanized.	285°	85	6.18
18	Green.	270°	80	6.75
18	Vulcanized.	270°	80	9.45
22	Green.	275°	90	5.22
22	Vulcanized.	275°	90	7.9

Experiments were made upon pine ties cut in two, one half vulcanized, the other half not vulcanized. The results are given in Table No. 1, and show the difference in absorption.

These specimens were treated with various degrees of heat and pressure, with and without vacuum, and in all cases they showed an increased absorption in the vulcanized over the unvulcanized timber.

The treatment of "green" lumber herein mentioned consists of simply putting the lumber in the cylinders and raising the heat to about the temperature of the liquid—say 200°—and then running the liquid in and keeping it there from 3 to 4 hours. Of course, this does not sterilize it or give as good absorption.

Other experiments were made upon ties, 6 ins. x 8 ins. x 8 ft., of long-leaf yellow pine, cut into three pieces, two of which were treated and the third left untreated. The results are shown in Table No. 2, the treated samples, 1 and 1-A, 2 and 2-A, etc., being the two pieces from the same stick.

TABLE No. 2.

	Absorption per cubic foot, in pounds.				Absorption per cubic foot, in pounds.		
	Above 10 lbs.	Bet. 8 and 10 lbs.	Below 8 lbs.		Above 10 lbs.	Bet. 8 and 10 lbs.	Below 8 lbs.
1	10.68			14	13.5		
1-A	10.12			14-A	14.62		
2	10.12			15	15.18		
2-A	10.28			15-A	15.74		
3		9		16	16.31		
3-A		9		16-A	13.5		
4			7.87	17		9.56	
4-A			7.87	17-A		9	
5			7.3	18		8.43	
5-A			7.3	18-A		8.43	
6			5.62	19	15.18		
6-A			5.62	19-A	15.18		
7	11.18			20			7.87
7-A	13.5			20-A		9	
8	12.96			22	13.5		
8-A	14.62			22-A	14.62		
9			7.87	23	16.31		
9-A			6.75	23-A	16.87		
10			6.75	24	12.92		
10-A			6.75	24-A	11.81		
11		9.56		25		9	
11-A			7.87	25-A		9.56	
12	12.93			26	13.5		
12-A	13.5			26-A	16.87		
13	12.37						
13-A	11.81						

As regards the spongy condition of the wood, after treatment by the creosoting process, an inspection of timber treated by the proposed process readily demonstrates that the timber is not in any way softened. The surface is subjected to treatment by the application of milk of lime after the creosote-resin has been injected. This tends to solidify the mixture of resin and creosote oil. Solidification to a point of brittleness is not effected, but solidification is effected to such a degree that the resulting surface of the wood is materially harder than that of untreated timber, instead of being softer, as is the case with creosoted timber. The writer has made tentative experiments to prove this hardening effect by striking treated and untreated sections of the same tie with a hammer. The greater density and hardness of the surface of the creosote-resin tie (about 50% increase in density near the surface) being readily apparent from the way in which it resists crushing under the hammer, the force of the blow causing the hammer to rebound from its surface instead of sinking in and crushing the fiber, as was the case with the untreated portion of the same tie.

Obviously, if it were commercially practicable to impregnate a railroad tie, of, say, long-leaf yellow pine, throughout its mass with creosote oil, no decay would take place in the timber so long as the oil remained in it. But such a treatment is impracticable, both because of its cost, and of the mechanical difficulties attending it. We therefore are obliged to fall back upon the plan outlined by Mr. Putnam in the letter previously quoted, namely, to secure complete sterilization, and to then inject sufficient of the preservative to effectually protect the remainder of the stick. This may be done by the injection of 8 to 10 lbs. per cubic foot in a standard-sized tie; 8 lbs., giving a penetration averaging at the center of the tie about $\frac{3}{4}$ to $\frac{7}{8}$ in., and 10 lbs., $\frac{7}{8}$ in. to $1\frac{1}{4}$ ins. at the center, with from 6 to 8 ins. inward from the ends of the stick in each case.

A tie treated by the above process, with say, 10 lbs. of preservative per cubic foot, possesses these advantages: It is thoroughly sterilized—a result not generally secured by the creosoting process—the outer fibers of the wood are filled with a material more highly antiseptic than dead oil of coal-tar, practically waterproof, and, when hard, considerably better able to resist crushing or cutting than is either the untreated or the creosoted timber. In fact, the spongy nature of creosoted timber, especially as the timber usually chosen for creosot-

ing is naturally soft, has been one reason why creosoted timber has not been more extensively used under heavy traffic. The experience of the Lehigh Valley Railroad was along this line. A tie treated by the process in question also possesses much higher spike-holding qualities—considerably higher than the untreated stick.

The writer has confined these remarks particularly to the subject of railroad ties; but it should not be overlooked that a large part of the business done by the creosoting works at present is upon piles and dock timbers; and the failure of such timbers when attacked by the teredo is invariable due to the washing out of the creosote oil by the action of the salt water. It would therefore be readily practicable to creosote piles, giving them either at the same time, or subsequently, a resin treatment to absolutely retain the creosote in the wood, and therefore the chief objection to creosoted piling would be at once removed.

The question of wooden paving blocks is also one having, in the writer's opinion, great possibilities. Wooden paving blocks, creosoted, are in extensive use in London and continental cities, and have given very favorable results in this country wherever properly used. If we add to the preservative effect obtained by the creosote oil the additional and most important benefit of so hardening the fibers of the wood that its resistance to wear is materially increased, we have realized a most material gain in the treatment of such blocks. In fact, if a treated pine paving block, protected against decay by dead oil of coal-tar, impervious to moisture and having considerably greater density and resistance to abrasion than either the creosoted or untreated timber, can be laid at a cost not greater than that at present charged for asphalt, it is the writer's opinion that such a pavement will possess all the advantages which asphalt possesses, and will be at the same time both noiseless and not slippery; thus removing two of the gravest objections to asphalt pavement. The writer thinks that such a pavement would have a longer serviceable life than asphalt—at least such as is generally laid—and on streets of a certain class be exceedingly desirable.

To revert once more to the question of tie preservation: With creosoting, as well as with the proposed improved process, the amount of impregnation per cubic foot is regulated by the specifications under which the work is done. For railroad ties the general practice is to use

about 10 lbs. Whether pure creosote or creosote and resin are used, this specification gives a depth of penetration at the center of the tie averaging nearly 1 in., and at the ends of the tie a complete penetration from the end of the tie of from 8 to 10 ins. Both with creosoting and with this process, the depth of penetration depends not only upon the amount of material injected per cubic foot, but also upon the nature of the timber and upon the individual qualities of different sticks of the same kind of timber. The writer has suggested as a possible disadvantage to such processes—whether creosoting or improved creosoting—the likelihood of the splitting of the tie taking place after treatment, thus allowing the introduction of germs into the heart of the stick. A careful examination and sawing of some fifteen to twenty ties, treated for periods extending up to 6 months, has shown no instance in which new cracks had opened in the timber and extended beyond the treated portion of the tie. Should this be the case after several years' service, the writer believes it to be true that the vulcanized heart of the tie treated by the improved process would better resist the action of decay than the untreated and unsterilized heart of the creosoted timber.

Further, it seems probable that water containing germs would to some extent get rid of such germs in passing through that portion of the timber which is antiseptic in its action. The results obtained with creosoted timber up to the present time do not indicate that such cracking or splitting, and consequent decay, are among the serious defects of the creosoting process. It seems reasonable to conclude that a tie which has been subjected to the continued high sterilizing temperature has developed splits in those weak portions where splits would otherwise have taken place under natural conditions, and these splits or cracks, developed in the earlier steps of the process, are filled with the antiseptic and waterproof material during the later stages, thereby excluding permanently both air and water.

DISCUSSION.

Mr. Prout. HENRY G. PROUT, M. Am. Soc. C. E.—This paper presents a proposition which is attractive, novel, and, so far as the speaker is aware, entirely original. Of course, the proposition to prevent the decay of wood by subjecting it to a sterilizing temperature is by no means new. About twelve years ago the process known as vulcanizing was exploited somewhat in New York City on precisely the theory advanced by Mr. Kummer, viz., that subjecting the wood to a high temperature would kill the germs, and that this temperature would solidify the albumen and other constituents of the sap and thus fill the pores of the wood with a solid, impervious, waterproof substance. The wood was treated under a high pressure also, to prevent checking. There should be by this time sufficient experience to show whether or not the expectations have been realized.

A large amount of vulcanized timber was put into use by the Manhattan Elevated Railway, in the tracks, station platforms and possibly elsewhere, ten years ago, or possibly longer. A considerable quantity was also put in service on the New York and Brooklyn Bridge by C. C. Martin, M. Am. Soc. C. E., and a large quantity was shipped to the Northwestern Elevated Railway of Chicago. From all these places we should now be able to get some information as to whether or not the vulcanizing process has any merit.

Obviously, however, the author thinks that vulcanizing is not thoroughly efficient. He must be quite familiar with its results, and yet he proposes to go further and supplement it by the addition of the antiseptic material and also the waterproofing resin. The speaker has always been skeptical as to the results of vulcanizing, because it has seemed inevitable that the transverse strength of the timber would be injured by heating it to such a high temperature.

In the early stages of vulcanizing, R. H. Thurston, M. Am. Soc. C. E., who was then at Stevens' Institute, made some tests of vulcanized sticks and reported that the transverse strength of the timber did not deteriorate under the process. The speaker has heard nothing further as to those results since Professor Thurston's tests.

Were it not for Mr. Kummer's statement, the speaker would also feel skeptical as to whether or not such a quantity of resin can be forced into the timber.

It is obvious that the high temperature treatment will develop checks in the timber—checks which are otherwise there, or would otherwise occur—and that those checks will be filled with creosote and resin which will, undoubtedly, add to the life of the timber.

The most important question is whether or not timber is actually injured by subjecting it to a temperature of about 300°, under pressure.

J. H. DEGHUÉE, Esq.—Vulcanized wood, with which the speaker has had some experience, has been used for the past 12 or 15 years. The wood was heated to a temperature of about 85° under a pressure of about 90 lbs. It has never been found that this treatment injured the fiber of the wood in the least. The speaker has seen the tests made by Professor Thurston and by others, and these tests showed that the timber was strengthened. The difficulty found with vulcanized wood was, that when it began to decay, that decay began at the surface, not at the heart. The sterilizing treatment was sufficient in that respect, and whenever decay began it was caused by contamination from outside, evidently by being washed by the rain water. Mr. Deghuée.

The process described by the author seems to be especially adapted to overcome that difficulty. It produces practically vulcanized wood with an antiseptic shell. It would seem that, as the heart of vulcanized wood never decays and an efficient antiseptic shell is provided, the process not only overcomes the troubles encountered with vulcanized timber, but also the objections to ordinary creosoted wood. In the latter, the objection is reversed, as the wood frequently decays at the heart on account of imperfect sterilization. Another objection is that it is soft, and does not resist the crushing strain. Creosote, although it may not be soluble, is washed out, perhaps by the mechanical action of the water. The speaker has experimented with wood treated by the process described in the paper, and has found that it actually shed water, the water running in drops on the surface. He has made soaking tests of the wood, and found that absolutely none of the material will dissolve. After soaking the wood for three or four weeks it was impossible to detect any of the preservative material in the water.

The term vulcanizing is probably only a trade name, given to the treatment on account of its being a heating process. In vulcanizing it has seemed to the speaker that the treatment is primarily a sterilizing process—simply a thorough sterilization of the wood—the secondary action being the decomposition of the sap and the production of a small quantity of wood tar creosote in the sap of the wood. This creosote is antiseptic, but the amount is rather small, and it has been found that it was not sufficient to prevent external contamination; that a fungus could grow in the wood if it could penetrate it from the surface, and that in time the surface would begin to decay. It is also probable that these antiseptic bodies which were produced by the heating were not strong enough to prevent that decay.

The theory that the elements of the sap were hardened and filled the pores with impervious substance has not been verified.

FRANK W. SKINNER, M. Am. Soc. C. E.—This paper gives an interesting description of a process which seems to be admirably adapted to secure the ends which are sought. Mr. Skinner.

Mr. Skinner. The principal requirements in connection with the process are: The seasoning of the wood and its sterilization at a high temperature, the extraction of the volatile substances in the timber, the operation of the vacuum for withdrawing the air, and injecting an antiseptic and waterproof substance. The question as to whether or not all these processes are desirable, are harmless or are beneficial, should be considered. The weight of evidence presented seems to be that the degree of heat maintained in seasoning and sterilizing is not to be considered as detrimental to the fiber or the strength of the timber.

The question as to whether or not the removal of all the volatile oils in the timber is detrimental has not yet been raised. The speaker doubts the advantage of removing them. He has positive assurances, from those whose investigations and judgment he greatly respects, that the extraction of all the juices of the timber impairs its strength and makes it brash. That point is worthy of discussion. Supposing that, however, to be settled in either way, we obtain a piece of timber which is supposed to have been sterilized; that is, admitting the decay of the timber to be due to bacterial agencies, the bacteria are all killed. After this the injection of the antiseptic material seems to be somewhat supererogatory. If the timber is to be filled with antiseptic material, why need it be sterilized first? If the material is an antiseptic, it should be an efficient one without sterilization, and it would seem that Mr. Kummer's formula for an antiseptic is likely to give very good results. The waterproofing and the constituents of the liquid seem to be desirable, and the speaker is of the opinion that it seems likely that the process should be preservative and increase the durability of the timber.

There are one or two points in reference to the manufacture which the author should make clear. In the first pressure treatment of the timber, is pneumatic pressure applied? Apparently, no liquid or water is introduced; so that it may be inferred that the first is an air process. Secondly, the schedule of time required for the treatment of the timber is stated to be twelve hours. Is that twelve hours of net time or of gross time? Can a charge of timber be brought from stock at 6 A. M. of a given day and be turned out as a finished product at 6 P. M. of the same day? If so, the process is materially more rapid than most of those with which we are familiar.

There is one point in the paper to which the speaker is obliged to take exception, viz., the statement that the impregnation with an antiseptic fluid is very difficult or impossible in the case of large timber. There is to-day established in Philadelphia a company which impregnates, to a hitherto undreamed-of extent, hard and soft timber of any merchantable size, 12 x 12 ins. or greater, right to the core. In that process a piece of timber is put in a retort and saturated to 120% in

from 40 minutes to three hours according to its thickness. A piece of white pine 1 in. thick can be saturated to 120% in 40 minutes, and a timber 10 ins. square is saturated to the same percentage in a little less than three hours. The treatment of hard wood requires about 40% more time. By 120% saturation it is meant that a stick of timber weighing 100 lbs. when put in the retort will weigh 220 lbs. when removed. This is effected in a closed retort by means of very heavy hydraulic pressure, about 500 lbs. for working pressure, and as high as 1 000 lbs. if necessary; and the apparatus is such that this pressure can be applied in a very few minutes. In a treatment, which the speaker witnessed, some pieces of timber were inserted in the retort, saturated to nearly 200% and taken out in 63 minutes, and the retort was ready for another charge. That is, a round trip was made in about an hour, so that the injection of antiseptic fluid can be made to the heart of timber of any size in length and cross-section. That process of complete impregnation, together with the formula and materials described in the paper, might lead to exceedingly valuable results. It might obviate the necessity of sterilization and possibly the necessity of high temperature in seasoning. Mr. Skinner.

The high-pressure process, just described, is not used for wood preservation, but for the purpose of making the wood non-inflammable. The speaker has made pine wood shavings $\frac{1}{64}$th of an inch in thickness, has placed a spoonful of them on a platinum plate and put that over a Bunsen burner and held it there in the fiercest flame for probably 10 minutes. They were not consumed; they were blackened and could be crumbled easily, but under no circumstances would they blaze. A block of wood 2 or 3 ins. thick, and thus treated, was placed in the furnace of a steam boiler and left there over night. In the morning it was charred on the outside, but had not been consumed.

Henry Goldmark, M. Am. Soc. C. E.—A comparison between the cost of the process described by the author and that of the improved chloride of zinc method would be interesting and instructive. There is little doubt that the injection of creosote preserves the timber longer, and under more unfavorable conditions, than any other process. It is, however, by far the most expensive means of protection. Mr. Goldmark.

The whole question of timber preservation is, after all, one of economy. The point is, not whether the ordinary or an improved creosote process is the best thing, but whether something else much cheaper will not, at least for railroad ties, serve a useful purpose. The German railroads have had an extended experience for many years with the Rutgers process. This consists in injecting chloride of zinc, with the addition of a small percentage of dead oil of tar. The theory of the method is, that the dead oil of tar will prevent the zinc salt, which is soluble in water, from being washed out.

The results, as given out by the company which does most of the

Mr. Goldmark. work, are extremely favorable. They are based on official investigations by the German government, and are believed to be reliable.

The cost of this improved zinc process is so much less than that of creosoting that it is more likely to be adopted on a large scale in this country than more expensive methods.

Mr. Cartwright. ROBERT CARTWRIGHT, M. Am. Soc. C. E.—The preservation of wood is very desirable, provided it can be accomplished at a minor expense. The speaker at one time burnettized a great deal of bridge timber. The process consisted of enclosing the timber in a tight receptacle and boiling out, as it were, the pyroligneous acid. Of course, being under pressure and in a water-tight, hermetically sealed tank, there was no opportunity for the oxygen to get at the acid. The hot water dissolved the acid and was then drawn off. Dry heat was then applied and a solution of sulphate of zinc was introduced under pressure and thereby injected into the tubes forming the wood fiber.

The speaker has frequently used a second time the clamps and keys from a worn-out bridge. The Indians frequently stole the ordinary timber, but would not touch the burnettized sticks, because they could not saw them nor split them, and the wood would not burn. The burnettizing process, however, was very expensive, and to-day the object is to get the best preservative for the least amount of money. It is said that the process described in the paper is economical, and this is a point in its favor.

Mr. Bogue. V. G. BOGUE, M. Am. Soc. C. E. (by letter).—Notwithstanding all the creditable work which has been done, we must confess, that, during the last 15 or 20 years, there has been but little absolute progress in the science of wood preservation. We know that the creosoting process is the most reliable, but no process has yet been discovered which can be fully depended upon in all situations and for all varieties or classes of timber.

The author states that the results obtained with creosote do not indicate that after treatment there often occurs such cracking or checking as to expose the untreated, heart portions of the timber to decay. This is contrary to the writer's observations. Only recently, in making some railroad examinations, he has found that, in the majority of instances, where creosoted piles had decayed, the trouble was clearly caused by checks which had occurred after the structures had been built. If the sterilizing process will quite fully develop the checks, without working damage to the timber, so that when the creosote is turned on it will reach all portions of the material which the air would ever be likely to reach, we may have in Mr. Kummer's suggestion a distinct advance. The writer would like to see the suggestion tried on a scale large enough to prove its value.

Mr. Osgood. JOSEPH O. OSGOOD, M. Am. Soc. C. E. (by letter).—This subject is an important one to all engineers who are called upon to protect

timber from the teredo or from decay, and has been treated by Mr. Kummer in a clear and interesting manner. Mr. Osgood.

If ties could be used without driving spikes or boring holes in them, the method of treatment suggested would probably prove more effectual than under present conditions of service.

If the penetration of the antiseptic material is only about 1 in. from the sides of the tie and 6 to 8 ins. at the ends, only half the tie is treated at the section where the spike holes occur, and decay at those points is not long delayed.

It is noticeable that a good quality of long-leaf yellow pine has been selected for the experiments. The heart of this timber is full of resin and is fairly durable without treatment. It is said, however, by those who make a business of treating timber, to be much less suitable for the purpose than the woods of more porous structure, and which, untreated, decay much sooner, but which will take up a much larger amount of the creosote or other treating material.

It would seem to be entirely reasonable that the injection of resin with the creosote should make the surface harder, and might serve to keep the creosote from washing out, but it would tend to lessen the effectiveness of the creosote as an antiseptic, and it does not seem probable that it would be at all effective against the teredo, which eats the resinous heart of long-leaf timber with great avidity, and requires a very strong dose of creosote oil to affect its appetite.

It has been stated that all decay in timber begins at the outside of the stick. This statement would seem to be subject to some modification, as it is not uncommon to find oak sticks hard on the exterior surface and rotten inside; and even long-leaf yellow pine is frequently destroyed by what is known as "red heart," a fungous disease, in which the heart of the stick is most affected.

As to forcing creosote into long-leaf pine for protection against the teredo: this is now done effectively by the Galveston Wharf Company at Galveston, only creosoted piles being used in the main wharves of that company, and these, the writer is informed, give satisfaction. It is said that these are impregnated with the heavier oils of coal-tar to the extent of from 20 to upwards of 25 lbs. per cubic foot, and the writer is informed by the Manager of the Creosoting Company which treated the piles for the present pile bridge of the Gulf, Colorado & Santa Fé R. R., across Galveston Bay, built a number of years ago, that 27 lbs. of heavy dead oil per cubic foot was used in them, or in as many of them as would take that amount.

Long-leaf yellow pine, when thoroughly creosoted, generally shows little of the heart wood which is not distinctly colored by the oil, although, in the piles coming under the writer's observation, there has always been some untreated heart. The timber appears to be much weakened by the process, and thoroughly creosoted piles will some-

Mr. Osgood. times break in handling, under circumstances which would not injure an untreated stick of the same timber. The timber seems to be very brittle. The great objection to creosoted timber at present is the expense. Inquiry, three years ago, when several thousand piles were required in a bulkhead to retain a filled wharf at Sabine, Tex., showed that the piles, which then cost about 6 cents per lineal foot delivered, would have cost over 40 cents per foot, if creosoted.

In treating piles great expense is caused by having to treat the whole length. Treatment is undesirable for the portion in the ground, where the teredo does not work, and is usually unnecessary above the water, so that it frequently happens that more than half the length of the pile is treated without any special benefit. Various ways of overcoming this difficulty, and of using creosote without distributing it where not needed, have been suggested, and some of them tried. Experiments are now being made with piles which have a 1½ or 2-in. hole bored through the center of each stick from the top to a little below the surface of the water, these holes being filled with creosote oil from time to time. The oil gradually distributes itself outward and downward, and, if this goes on rapidly and thoroughly enough, will, it is argued, reach the exposed surfaces of the piles and prevent the ravages of the teredo.

An attempt has also been made to stop the progress of the teredo, in piles already slightly affected, by boring a slanting hole at about mean low water and reaching down as far as possible without going through the stick. These holes, of 1 or 1¼ ins. diameter, are filled with creosote oil at intervals as the tide permits and as the oil soaks away. The holes are kept plugged at the top to prevent waste. It is too early to determine whether either of these experiments will prove effective or of any value.

A writer in one of the engineering periodicals not long since called attention to a method of forcing liquids into timber through a cap on one end of the stick, which permitted a pressure to be applied to force the liquid lengthwise through the pores of the wood. This would seem to offer advantages in treating piles, as the process could be stopped when any portion of the length had been saturated, and probably a hole bored in the middle of the stick, nearly as far down as it was desired to distribute the oil, would be of service in this connection.

Mr. Whinery. SAMUEL WHINERY, M. Am. Soc. C. E. (by letter).—In discussing any method for the preservation of timber, the conditions under which the wood is to be used must be considered, and the character and extent of the preservative process should be suited to resist the causes of disintegration to which the wood will be subjected.

When exposed to brackish water, wood must be protected against the ravages, both of ordinary decay and of the teredo. When used for railroad ties, and generally for structures on land, it is necessary to

make provision against ordinary decay only. For the latter purpose it would seem that any process which, like that under consideration, first thoroughly sterilizes the timber throughout its whole mass, and then fills the cells to a greater or less depth from the surface with a permanent material which will exclude air and moisture, would prove efficient. It is not even necessary that the sealing material should penetrate the wood at all if the surface can be made impervious to air and moisture and maintained in that condition. If these assumptions are well founded, wood-preserving processes may cover a wide latitude, and there should yet be plenty of room for invention. The modified process of creosoting wood described by Mr. Kummer is rational, and should be efficient, particularly in preserving railroad ties. Mr. Whinery.

Those who have had occasion to work in the yellow pine forests of the Southern States know that the endurance of the "pine knots" is proverbial. When the public lands of those States were originally surveyed by the Government, these pine knots were frequently used for corner stakes or monuments, and they have often been found in place in a perfect state of preservation after being in the ground for more than thirty years. The principal peculiarity of these knots is that they are often perfectly saturated with pine resin, and their practical indestructibility is, without doubt, due to that fact. The process under discussion seems to be an approach to this wood-preserving process of Nature.

Horace J. Howe, M. Am. Soc. C. E. (by letter).—Referring to the tie question and the apparently prohibitory cost of treating the whole tie, it should be borne in mind that the life of the tie is the life of the portions adjoining the rails, and that in first-class, well drained ballast it is the top half of the stick at those points which suffers most, and necessitates renewal. Cannot a method of treating them be devised under these conditions? Mr. Howe.

In looking over piles of old ties taken from the track, one is struck with the fair condition, in most cases, of the middle portion of the tie, say for 4 ft. in length. The ends are split, owing to various causes, one of which is that trackmen, in originally placing the new tie, are allowed to use picks freely. Thus the ends are split off, and, naturally, cracks develop and rot sets in near the rails.

The heart of the tie being on the under side requires less attention than the top. Let the tie be dapped under each rail for 12 ins. in length, and let four spike holes at each end be bored by template for the pattern of rail to be used. It is stated by W. W. Curtis,* M. Am. Soc. C. E., that this can be done, in connection with the treatment, at a cost of about 3 cents per tie. Could not each tie be treated at these two places for a total length of 2 ft., with or without an isolating chamber?

* *Transactions*, Am. Soc. C. E., Vol. xlii, page 373.

Mr. Howe. The holes would distribute the preservative to the points where it was most needed, and the waterproof quality of Mr. Kummer's mixture, for instance, would take effect on top.

It looks as if the expense might be reduced considerably, say one-third, in comparison with the corresponding treatment of the whole tie.

It might be said that the tie would be unfavorably affected by difference in homogeneity, but this would have to be determined exactly by experiment.

Mr. Moncure. WILLIAM MONCURE, M. Am. Soc. C. E. (by letter).—The preservation of timber is a subject which has been discussed extensively, but, as yet, there seems to be no method by which the cost is brought within practical limits. The cost of the method proposed by Mr. Kummer is not given.

In 1886, in the construction of one of the southern railroads, all the signal and mile-posts were made of long-leaf North Carolina pine, the entire log being used, without any regard to the quantity of sap or heart. These posts were 4 x 6 ins., and the part above ground was painted with three coats of white lead in linseed oil. The lower part, up to a point just above the surface of the ground, was placed for 15 or 20 minutes in an open kettle containing 50 % of pine tar and 50% of resin, the mixture being kept above the boiling point. These posts are standing now, and when examined two years ago showed no signs of decay. The cost of this process did not exceed 15 cents for each post. It is possible that the wood was thoroughly dried by the heat, and that the tar and resin filled the outer pores, leaving also a coat outside which prevented the entrance of moisture.

The oak tie, without doubt, is best suited for roads where there is heavy traffic and much curvature, and seems to be the most difficult to preserve by the creosoting or any similar process. Investigations seem to have been directed almost entirely to creosoting or similar processes, and, so far, seemingly without practical results. It is possible that if investigations were made in the direction of drying the timber and coating the outside with a substance which would prevent the entrance of moisture, some method might be found which would bring the cost within a practical limit. There is a cypress in some of the Southern States which has been used for ties and has lasted for 25 years, but cypress is objectionable because the wood is soft; the rail cuts the tie, and the spikes do not stay in place, thus causing the track to get out of gauge. These objections can be overcome by the proper use of tie-plates, and a cypress tie with tie-plates ought to especially recommend itself to roads on which the curvature, gradients and traffic are light.

The question of obtaining ties is at present of great importance to the maintenance-of-way departments of railroads, and these notes

are presented with the hope that this subject will be continually kept in view and result in developing some practical method which will be within the means of any railroad. Mr. Moncure.

J. I. Boggs, Assoc. M. Am. Soc. C. E. (by letter).—In discussing the paper by Walter W. Curtis, M. Am. Soc. C. E., the writer gave the results of some observations on creosoted pine ties along the line of the Houston and Texas Central Railway.* These ties had seen 20 years' service, and it was estimated that fully 80% of the original number was yet in the track. The objections to them were: First, the soft wood used, which permitted the rail to cut into the timber very badly; Second, their high price. Mr. Boggs.

These observations were recently confirmed by M. G. Howe, M. Am. Soc. C. E., the present Engineer of Maintenance-of-Way, and by G. A. Quinlan, M. Am. Soc. C. E., the General Manager of that road, in a late issue of *Engineering News.* Twenty years ago Bethell's process was still in its infancy, and, owing to its excessive cost, managers hesitated to use it, except to a very limited extent; but with the facts deduced from our past experience, certainly none can justly say that "no process has yet been discovered which can be fully depended upon" for the preservation of timber, and it appears to the writer that the time for hesitation is past, especially when we consider the depleted condition of our forests.

The writer has seen some rotten creosoted piling, but in nearly every case this was caused by the bridge carpenters cutting off the ends of the sticks after the piling was driven and neglecting to apply the hot preservative to the exposed end, thereby permitting it to absorb moisture from the atmosphere for days and sometimes weeks at a time. In other cases this decay may be attributed to the treatment of defective timber.

The writer has never been troubled with rot caused by the checking of the creosoted pine timbers after they were in the structure.

It is unfortunate that a great many of our co-workers imagined the poorest class of timber to be the best for creosoting purposes, because it has given rise to the fallacy that "the timber is much weakened by the process." The fact is, if the timber is properly treated, the dead oil neither adds to nor detracts from its strength; but, in nearly every case, comparisons are made between the very poorest and the very best material, the result being the hastily and erroneously drawn conclusion that "the process weakens" it. The writer has seen "thoroughly creosoted piles sometimes break in handling," but close investigation in each instance has shown that originally they were of the poorest pine, such as is known as the "Loblolly"; that they were stacked in the yard to "dry out" for two or three months before being treated, and were, in fact, rotten before the oil ever touched them.

* *Transactions*, Am. Soc. C. E., Vol. xlii, p. 348.

Mr. Boggs. R. Montfort, M. Am. Soc. C. E., Chief Engineer of the Louisville and Nashville Railway, is in a better position than anyone known to the writer to speak with authority on the action of the teredo on creosoted piles, as his line traverses a number of salt water inlets along the Gulf Coast, and probably owns one of the oldest creosoting plants in the country. It is the writer's impression that he has entirely abandoned treating his piling, and is now protecting it with salt-glazed sewer pipe, as creosoting did not protect against the teredo. The Gulf, Colorado and Santa Fé Railway had a similar experience at Galveston, Tex. About the year 1881 they built a creosoted pile trestle, about 2½ miles long, across Galveston Bay. It lasted about 2 years, and was then rebuilt with elm, which, of course, required constant renewals, at a cost of about $1 000 per month. This continued until 1897, when they rebuilt with creosoted pine, with what results the writer is not in a position to say.

The writer once experimented on pine poles containing nothing but sap. The poles were cut in the spring and completely immersed in fresh water. The following spring they were found to have turned into "lightwood," that is, heavy, resinous, pitch pine. They were then placed in salt water, and, up to the following fall, the teredo had failed to attack them to any material extent; hence the writer believes the use of a percentage of resin in the processes of either Bethell or Burnett would be very beneficial; but, that the dead oil of coal-tar will ever alone protect against the teredo, is, in the light of past events, very doubtful.

The prevailing custom of subjecting only the poorest class of timber to the creosoting process is to be greatly deplored, and when a better material is more extensively used very high results may be confidently expected. The use of very high temperatures will unquestionably kill the germs, but, unfortunately, will kill the fiber of the timber also.

Mr. Curtis. Walter W. Curtis, M. Am. Soc. C. E. (by letter).—The engineering profession should be ready at all times to give a hearing to the advocates of any new processes affecting the materials of construction; and to test such processes when it is possible to do so without too great expense; or when the possible resulting failure can be determined before the expenditure has become very large.

There is now, and will be in the future to a greater extent, a strong desire to experiment with new wood preservatives. The two methods now in use are old. The evidence of their value, in the writer's opinion, is sufficient to justify their general adoption, but is not as complete as could be desired, and, from the nature of things, is not likely to be. The difficulty of keeping tie records on long lengths of road for 15 and 20-year periods is such that those who desire to find fault with them will always have opportunity. One of the greatest

dangers to the cause of timber treatment in this country is likely to be this desire for something new—and cheap. Mr. Curtis.

In the writer's study of the question, it has been very amusing and instructive to read the circulars and endorsements therein, of 20 years ago, of methods long since gone by the board. It seems almost necessary to demand of the advocates of every new treatment, that it should first be tested for 10 or 15 years and then presented to the attention of the public. Certain it is that nothing short of such a test can be considered as conclusive, as to comparative value, in the case of ties.

Evidently, however, all engineers do not take quite such a pessimistic view of the matter. A committee of one of the Associations of Engineers of Maintenance-of-Way recently reported very strongly recommending the general adoption of a method of treatment of ties by painting them with or dipping them in a certain preservative compound; the advice being prefaced with and based upon a statement that by such treatment a life of 18 years could be secured from timber naturally having a life of but 6 years. The evidence to support such claims is very small and entirely insufficient to warrant any such general recommendations. In the advertising matter regarding one of the most recent processes offered the public, is the report of a learned professor, in which it is asserted that a life of from 13 to 15 years can be secured from soft wood ties treated by this particular method; and the evidence on which this is based is that poles so treated and placed in soil favorable to decay were sound after 2½ years.

The writer does not intend to decry either of these processes; they may be of great value, but the evidence thereof, as applied to ties, is extremely limited.

Mr. Kummer describes a treatment intended to overcome certain mechanical difficulties "in connection with creosoting, particularly railroad ties." Evidently, he refers to the fact that creosoting does not harden timber and that the usual allowance for ties, 10 lbs. of creosote per cubic foot, does not completely saturate the wood. This is undoubtedly true, but it seems hardly fair to condemn creosoted ties therefor, without some more definite data as to actual bad results. The recorded history of creosoted ties in the United States is not very great, but, so far as it goes, does not indicate that the deterioration from rail cutting is so serious as to detract greatly from the value of the treatment.

If Mr. Kummer has shown a means whereby such difficulties as do exist, however great or small they may be, can be removed, he has earned the thanks of the profession; but we must be careful lest, in running from the troubles of which we know, we do not also leave good qualities of which we are certain. As the paper did not state the comparative costs of the creo-resinate treatment and ordinary creosoting,

Mr. Curtis. the writer inquired of the company operating the process, and was told that the costs were the same, using equal amounts of preservative material in each case. For a tie creosoted with 9 to 10 lbs. per cubic foot the English records show a life of from 16 to 20 years; using a rail supported in a cast chair. If creosoted ties here are provided with tie-plates, at an additional cost of about 10 cents, there is every reason to expect as long service; indeed, Mr. Boggs, in his discussion* of the writer's paper, states that on the Houston and Texas Central R. R. 80% of the creosoted ties laid there in 1877 were still in service after 20 years, and that without a tie-plate.

The author's remarks as to the necessity for complete sterilization in creosoting are no doubt correct. In this respect the chloride of zinc treatment has an advantage, for, while sterilization there is probably advantageous, the use of heat is primarily to so season the wood and open the ducts, as to permit the entrance of the preservative fluid. This completely saturates the timber, if properly done, and the preserving and toxic agent is deposited throughout all parts of the timber. There is a decided lack of data as to the penetration of heat into ties during steaming, and the figures given in the paper are welcome and pleasing as well, demonstrating, as they do, the thoroughness of the steaming in Burnettizing. Mr. Kummer states, "with a temperature of 230° Fahr. in the cylinder, 178° was secured at the center (of the tie) in 2 hours, while with 290° at the outside, 249° was secured in 2 hours." Presumably, the 2 hours referred to is the time interval between the admission and exclusion of steam to and from the cylinder. In Burnettizing, it is customary to steam for at least 3 hours, the temperature being from 250° to 260° Fahr. The mean of the two cylinder temperatures given by Mr. Kummer is 260°, and the mean of the resulting tie temperatures is 213½°; so it is reasonable to conclude that the usual practice in Burnettizing results in complete sterilization. With reference to the use of a higher temperature under pressure, without injury to the timber, the writer has no data. He is not satisfied with any explanation of the philosophy of it, known to him, but the evidence seems to support the claim. The danger to be feared is not so much the checking of the wood, as the breaking down and disintegration of the fiber. It would be very interesting to know the relative absorption of preservative by timber treated according to the author's method and by the use of heat of 250° for the same length of time without pressure.

Table No. 1 shows the amount of absorption of preservative in green and in vulcanized timber. It is well known that it is impossible to inject any large amount of anything, even water, with the usual pressures and time of application, into timber which has not first been prepared for it by steaming. Before the value of vulcaniz-

* *Transactions*, Am. Soc. C. E., Vol. xlii, p. 348.

ing can be admitted as a preparatory treatment, it must be shown that Mr. Curtis. steaming at the usual heat would not secure the same results. Even if the time of such steaming with 250° temperature was one or two hours longer, in the writer's opinion, it would be much safer.

Table No. 2 shows the uniformity of absorption—or lack thereof. It will be noted that the range is from 5.62 to 16.87 lbs. per cubic foot; the variation being just 200% of the lower extreme. Evidently, vulcanizing is not successful in entirely eliminating the idiosyncrasies of wood.

Mr. Kummer states that thorough sterilization is not generally secured during creosoting treatment. The writer understands that creosoting works generally use as high temperatures in steaming as do Burnettizing works, and continue it for as long or longer periods. What evidence has the author that the temperature of 212° at the center of the tie is not secured in creosoting?

The use of the creo-resinate process is recommended by the author for marine work. The writer recently received a letter from Mr. J. W. Byrnes, Superintendent of the timber treating works at Beaumont, Tex., whose experience in this line extends back some 30 years.

He states that Mr. J. W. Putnam made a test of a combination of resin and creosote, while operating the works at Pascagoula.

"He treated a quantity of sheet piling for the Galveston Wharf Company, about 10 years ago, and in less than 2 years the teredo had completely destroyed the wood. The President of the Wharf Company appointed me as the arbitrator in their behalf, and I recommended that Mr. Putnam be allowed to act in his own behalf. We had the piling cut out at the point of greatest exposure and divided them into short cuts and split them in small sections. The wood showed a perfect saturation, but, while only one-third resin had been used to two-thirds oil, there was no odor or sign, other than color, that would indicate that a particle of dead oil had been used. The resin had totally destroyed the quality of the oil as a preservative against the teredo. About 1869, one of the leading chemists and physicians of New Orleans conceived the idea of treating wood with a mixture of resin-oil and resin, for marine use. We were at that time distilling resin-oil in connection with our coal-tar distilling works. We treated a number of samples of 4 x 4-in. pieces which he had fastened to piling or other structures at Lake Pontchartrain, Biloxi, Mississippi Sound, and Fort Phillip and Fort Jackson, at the mouth of the Mississippi River. The treatment seemed to give the wood a relish for the teredo. The Biloxi test was destroyed totally within 2 years. The Lake Pontchartrain and mouth of river samples held out for a year or two longer, but none to a greater extent of time than the natural wood. While the treatment of wood with a mixture of dead oil and resin may be effective as a preservative against decay, it has been positively proven by thorough tests that no good results will be obtained when used for marine work."

The process described by the author differs somewhat from that followed by Mr. Putnam; and it may be that the differences are sufficient to secure a more happy result. As a matter of history, however, the foregoing should be recorded.

Mr. Curtis. Mr. Byrnes is strongly of the opinion that, to get satisfactory results from creosoted timber in marine work, it must be allowed to dry out for from 30 to 60 days after treating, when the creosote in the outer part of the timber becomes thick and gummy. If this is done, and the treatment has been properly given, he is satisfied that no difficulty will be experienced with the washing out of the creosote; and the durability of the work will prove satisfactory.

It is to be hoped that future experience with the creo-resinate treatment will demonstrate its value to be as great as the author anticipates. The writer, however, is less interested in improving upon creosoting practice than in approximating the results secured thereby at a less cost. The great need of the railroads to-day is to demonstrate or confirm the value of the zinc-chloride treatment; and to improve thereon.

Mr. Montfort. R. MONTFORT, M. Am. Soc. C. E.—The writer's attention has been called to Mr. Boggs' discussion, in which the following statement is made:

"R. Montfort, M. Am. Soc. C. E., Chief Engineer of the Louisville and Nashville Railway, is in a better position than any one known to the writer to speak with authority on the action of the teredo on creosoted piles, as his line traverses a number of salt water inlets along the Gulf Coast, and probably owns one of the oldest creosoting plants in the country. It is the writer's impression that he has entirely abandoned treating his piling, and is now protecting it with salt-glazed sewer pipe, as creosoting did not protect against the teredo."

Mr. Boggs is mistaken in his impression. The Louisville and Nashville Railroad Co., during the past twelve months, constructed a large dock and warehouse at the foot of Commendencia Street, Pensacola, Florida, in which some 6 000 creosoted piles, averaging 70 ft. in length, and treated with 20 lbs. of creosote oil per cubic foot, were used. In addition to this, during the same period, about 2 000 000 ft. of sawed timber were used by this company on the wharf referred to, and for bridges, culverts, etc. It certainly, therefore, cannot be said that the Louisville and Nashville Railroad Company has entirely abandoned the use of creosote oil for protecting piling and timber against the teredo and against rot.

It is true that after a service of 14 years the creosoted piles in trestles across Biloxi Bay, and Bay St. Louis, on the New Orleans and Mobile Division, and across Escambia Bay, on the Pensacola and Atlantic Division of the Louisville and Nashville Railroad, were found to be attacked to a more or less serious degree by the teredo, and the piles in these trestles were further protected against the teredo by concrete or by vitrified clay pipe as described in a paper by the writer, read before this Society November 1st, 1893.* The same creosoted

* *Transactions*, Vol. xxxi, p. 221.

piling, driven in 1878, namely: 2 626 piles at Bay St. Louis, and 1 648 piles at Biloxi Bay, or a total of 4 274 piles, with the exception of 3 that have been replaced by new piles on account of rot, and 122 piles that were destroyed by the hurricane of October 2d, 1893, are still in use, giving good service, and with prospect of lasting several years to come. Untreated piles at these bridges would not last, on an average, more than 7 years as against rot, or 6 months against the teredo. Mr. Montfort.

Mr. Boggs does not state as to the treatment adopted, or the quality of the oil used in the piles of the Gulf, Colorado and Santa Fé Ry., at Galveston, Texas, which gave such poor results. From the writer's experience he is inclined to think there must have been some defect, either in the treatment or in the quality or quantity of the oil used that caused such results.

The writer believes Mr. George S. Valentine, who for years has been in charge of The Eppinger and Russell Company's creosote works, Long Island City, N. Y., treated piles in the early 70's that were driven in Galveston Bay, and are still doing service if they have not been destroyed by the recent hurricane.

In discussing the paper referred to, the writer said: *

"In recent years, we have been experimenting with a mixture of resin and dead oil, with the hope that the resin will aid in fixing the oil and prevent it from being dissolved or washed out. Sufficient time has not elapsed to form any definite conclusion, although, so far, piles thus treated have given satisfactory results."

It is to be regretted that further experience with piles treated with dead oil of coal-tar and resin has not given the satisfactory results hoped for. In 1890, it having been found that the teredo had commenced to attack the piles in piers of East and West Pascagoula River bridges, driven in 1876, it was decided to strengthen the piers by replacing two piles at each end of each pier, consisting of sixteen piles. These piles were 80 ft. long, 10 ins. in diameter at the small end, and were driven 40 ft. into the bottom of the river. They were treated with a mixture of resin and oil in the proportion of 45 barrels of resin to 30 barrels of creosote oil, which is about the same proportion Mr. Kummer proposes to use. The total number of piles treated in this way and driven at these bridges was 88.

A recent examination of these piles for rot, by boring, showed that of the inside piles driven in 1876, and therefore 24 years old, only 8% showed rot in the heart, while of those treated with the mixture of oil and resin, driven in 1890, and only 10 years old, 43% showed rot in the heart. An examination by diver showed that the piles 24 years old, originally treated with creosote oil, were in better condition than the piles only 10 years old treated with the creosote oil and resin mixture.

From this it will be seen that the idea of mixing resin with the creosote oil did not originate with Mr. Kummer, but was used by the

Transactions, Vol. xxxi, p. 246.

Mr. Montfort. late J. W. Putnam, Assoc. Am. Soc. C. E., who did the work referred to, under contract, more than 10 years ago.

The writer hopes that Mr. Kummer's experience with piles so treated will be better than the results obtained on the Louisville and Nashville Railroad.

Mr. Felt. C. F. W. Felt, M. Am. Soc. C. E. (by letter).—Some of Mr. Boggs' statements in reference to the bridge of the Gulf, Colorado and Santa Fé Railway Company across Galveston Bay are inaccurate. The facts in relation to the original Bay bridge are as follows:

This bridge (about 2 miles long) was built in 1875. The contract for the treatment of the piles specified the use of 8 lbs. of creosote per cubic foot. As nearly as the writer can ascertain, the treatment was not carefully done, and was not uniform. Mr. Byrnes, who had charge of part of it, has stated that some of the piles were treated with a much heavier amount than that specified in the contract. Mr. B. M. Temple, then Chief Engineer of the road, reported seven years later that about 50% of the piles had been destroyed; and in 1895, when the bridge was removed, about 5% of the original piles were still intact.

In 1895 the bridge was rebuilt. The piles were of long-leaf pine, treated with 24 lbs. of creosote to the cubic foot, and at this writing they have not been attacked by the teredo.

Mr. Valentine. George S. Valentine, Esq. (by letter).—In May, 1874, in conjunction with Mr. R. S. Trundy, the writer built a small creosoting plant at Galveston to treat paving blocks, which were afterward laid on Market street, in that city. The lumber used was the ordinary sound and square-edged yellow pine, which was treated with 12 lbs. of dead oil of coal-tar per cubic foot, and laid under the Stow patent, which consisted in a wedge being driven between each row of blocks for half the depth of the block. The blocks were 6 ins. deep and 4 ins. wide. The wedge was 6 ins. long and 1 in. thick, and was driven into the ground 3 ins. This left between each row of blocks a groove 1 in. wide and 3 ins. deep, which was filled with fine gravel and a mixture of asphalt. This pavement is still in good condition. A few years ago, when the motive power of the railroad was being changed from mules to electricity, the contractor, Mr. J. W. Byrnes, of that city, offered a reward of $50 to anyone who could find an unsound block among those which were taken up, and, although a great many persons were searching, he did not have to pay the reward.

Before the writer left Galveston, late in the fall of 1874, the Galveston Wharf Company and the Galveston, Houston and Henderson Railroad were negotiating with him for some creosoted piles. These piles were treated at our works by J. W. Byrnes of Galveston. Some of them received a light treatment and some a heavy treatment. Those receiving the light treatment were not a success, but those treated with 20 lbs. of dead oil of coal-tar per cubic foot are now in

use, and some which were taken up a few years ago showed no sign of decay or the effects of the teredo, although that insect will destroy an untreated pile in less than one year. Mr. Valentine.

In regard to the creosote and resin process, the late J. W. Putnam, of New Orleans, who was an authority on wood preserving, took out two patents for such a process, Nos. 405 907 and 405 908, dated June 25th, 1899. He had been experimenting with these compounds a long time before he gave it up some years ago, pronouncing it a failure.

The writer has made a large number of experiments with various compounds in order to find a material which would take the place of dead oil of coal-tar and cheapen the cost, but, so far, has been unsuccessful.

F. A. Kummer, Jun. Am. Soc. C. E. (by letter).—Mr. Curtis rightly says that the objections to creosoting, at present existing, are not sufficient to condemn it, and the writer certainly had no intention of making such a statement. On the contrary, the advantages of creosoting are such as to very generally recommend it, and Mr. Octave Chanute's very interesting paper* goes to show that creosoting, either in its usual, or in a modified form, is fast supplanting all other processes in European practice. Its disadvantages, however, are quite generally known, and therefore it would seem to the writer that any attempt to remove them by improving the process is a step in the right direction, and in this he feels sure that Mr. Curtis will agree with him. Mr. Kummer.

As for the recorded history of creosoting in the United States not showing that rail cutting is a serious obstacle to its general use, the writer must disagree with Mr. Curtis entirely, so far as eastern roads or those having heavy equipment and traffic, are concerned. The Manhattan Elevated Railroad published a report, during the management of the late Colonel Hain, in which it was directly stated that creosoting decreased the spike-holding qualities of the tie and increased rail cutting, and substantially stated that vulcanizing increased spike holding and decreased rail cutting. In England, the rail and chair construction, and the lighter equipment, does not make this question so vital. Tie-plates at considerable expense would help to remove the trouble in this country, so far as rail cutting is concerned, but not with reference to spike holding. This is the position taken by the Lehigh Valley Railroad, as records of discussions before the New York Railroad Club will show, and this road should be in a position to speak authoritatively, as they for some time owned and operated a creosoting works at Perth Amboy, now no longer used for that purpose.

The fact that creosoted ties have lasted without serious rail cutting,

* "The Preservation of Railway Ties in Europe," presented to the Society, October 17th, 1900.

Mr. Kummer. on the Texas Central Railroad for 20 years, does not by any means indicate that they would do this on the New York Central or on the Pennsylvania. The question seems to turn largely on the character of the timber used. In the East the great scarcity of chestnut and white oak is driving the eastern roads into the use of long-leaf yellow pine, a class of timber not readily treated by any method of preservation, and especially difficult when subjected to treatment by any of the processes in which water is used for carrying the antiseptic salt into the timber, owing to the highly waterproof nature of the natural pine resins. The great and increasing use of yellow pine by eastern roads, makes the treatment of that timber a desideratum. A gentleman, whose experience in the use of the Burnettizing process has been of the widest, recently stated that it is not practicable to satisfactorily Burnettize resinous long-leaf yellow pine at reasonable cost. The use of softer woods, with tie-plates, is no doubt readily possible, but outside of the question of crushing comes the equally serious question of the spike-holding qualities of the wood. It is the writer's opinion that while retaining all the advantages of creosote as a preservative, advantages which have led to the almost universal discarding of all other antiseptics in its favor in England and on the continent, the creosote-resin process very greatly increases the spike-holding qualities of the timber, while at the same time greatly increasing its resistance to crushing. These are mechanical questions and should be readily susceptible of proof. The experiments and tests which have been conducted and are now being conducted by the United States Wood Preserving Company at Perth Amboy and elsewhere, demonstrate this. If these results are not accepted, the writer feels sure that that company will not only be ready to furnish samples at any time for independent testing and investigation, but will place its plant at the disposal of the Society, or its members, at any time, with every opportunity for the making of experiments to demonstrate, not only their claims as to resistance to crushing, etc., but as to the complete sterilization of the timber, the absorption of the preservative fluid per cubic foot secured, and the length of time required. The writer makes this statement on the authority of the United States Wood Preserving Company, with which he is in no way connected.

The writer is glad to find that Mr. Curtis agrees with him in the necessity for complete sterilization. If such sterilization is generally secured in the Burnettizing process, so much the better for that process—but the figures given by Mr. Curtis do not demonstrate it completely. It is more difficult to secure a sterilizing temperature at the heart of a stick by steaming than by using dry heat under pressure. Experiments have shown that the penetration of heat is more rapid when wood is treated in this manner than when treated with steam at the same temperature—the explanation of this being that the water

condensing in the outer pores of the wood, and being a very bad conductor of heat, prevents the temperature at the center of the wood from rising as rapidly as it would otherwise. On the other hand, in the treatment by means of dry air, the hot air, being under pressure, is forced into the wood and assists in causing the temperature to rise. When these facts are considered, Mr. Curtis's conclusions, drawn from the figures in the paper, are not convincing. It is true that when these figures are averaged an outside temperature of 250° would give a temperature of 213½° at the center of the tie, but this is with hot dry air under pressure. If steam at 250° were used, this temperature at the center would probably not be obtained except at great loss of time. To use a higher temperature than this in the case of steam, or to keep the wood at this temperature for a much longer time, would injure the fiber of the wood. Mr. Kummer.

The whole idea of "vulcanizing," so-called, was to sterilize large timbers without injury to the fiber, by the use of hot dry air under heavy pressure. It has been intimated that vulcanizing caused no injury to the fiber of the wood, or impaired its strength, and this opinion is fully borne out by tests on vulcanized wood, made by Professor Thurston and others. The radical difference between the two methods of sterilizing, steaming and vulcanizing, lies in the use in the latter process of air pressure up to 90 or 100 lbs. to fully prevent ebullition or boiling under the high temperature used. It is the writer's opinion that unless sufficient pressure can be used to prevent boiling, it is not safe to subject timber to temperatures sufficiently high to produce complete sterilization in a reasonably short time. Mr. Curtis says:

"It is well known that it is impossible to inject any large amount of anything, even water, with the usual pressures and time of application, into timber which has not first been prepared for it by steaming."

This is certainly not a fact, since the company operating the creoresinate process is doing this very thing daily on large contracts. Mr. Curtis also says:

"Before the value of vulcanizing can be admitted as a preparatory treatment, it must be shown that steaming at the usual heat would not secure the same results."

Why must this be shown? Even if steaming at the usual heat would secure absolute sterilization in a reasonable time without injury to the fiber—which the writer does not believe—what advantage has steaming over vulcanizing in the treatment of yellow pine timber?

Mr. Curtis is quite right in saying that vulcanizing as a preparatory treatment does not eliminate the idiosyncracies of timber, and, of course, this is not claimed for it, or indeed for any other reputable process. It is only those processes, new or otherwise, for which perfection is claimed, that really tend to throw the whole subject of wood preservation into disrepute.

Mr. Kummer. The only evidence the writer has that the steaming temperature generally used in creosoting does not in the time allowed give absolute sterilization is the demonstration afforded by experiments conducted with self-registering thermometers to determine this fact. The writer has believed for some time that the great importance of complete sterilization is generally overlooked; but if Mr. Curtis has any evidence to the contrary, he is very glad to know it. The experiments were not made for the purpose of casting any discredit upon creosoting as generally done, or in fact upon any other process, but merely to insure the absolute certainty of sterilization in the particular process which formed the subject of the paper.

With reference to the use of the process for marine work, there is no scientific basis for the action of resin upon creosote as described by Mr. Curtis, and yet the results may be as described. The writer, however, believes that piles treated with creosote proper (and not with a mixture of creosote and resin as tried by Mr. Putnam) would have a much longer life if the washing out of the creosote oil could be prevented by a surface treatment of resinate of lime, as outlined in the paper. No claims are at present made for the use of creosote-resin as a protection against the teredo, although the writer understands that experiments are now being made to demonstrate its value in such service.

In view of Mr. Curtis's closing paragraph, that the great need of the railroads to-day is to demonstrate or confirm the value of the zinc-chloride treatment and to improve thereon—the following extracts from Mr. Chanute's paper* may prove interesting:

"*Great Britain.*—All antiseptics, save tar-oil, have now been abandoned in England, where 'creosoting' so-called, has grown to be recognized as the best process to use."

"*France.*—The latter substance (creosote) is now practically used exclusively by all the roads, save those of the State, which use a mixture of chloride of zinc and creosote, which will be more fully noticed when the German practice is described. 'Burnettizing,' *i. e.*, the injection of chloride of zinc alone has been extensively used, but is now abandoned, as the zinc is found to wash out in time, specially in moist situations."

"*Germany.*—Corrosive sublimate and sulphate of copper are now practically given up in Germany, and the State Railway also abandoned Burnettizing or the injection of chloride of zinc by itself in 1897. There are now three processes in use:

"1. Impregnation with chloride of zinc and tar-oil.

"2. Creosoting after seasoning and drying in ovens.

"3. Creosoting after desiccation in hot tar-oil."

The reference to creosoting, after seasoning and drying in ovens, does not indicate any great necessity for steaming, which Mr. Curtis regards as a *sine qua non.*

Mr. Chanute's objection to creosoting in the United States is its

* "The Preservation of Railway Ties in Europe."

cost, but there is no doubt that the conditions of service on heavily-traveled eastern roads, with frequent trains, heavy equipment and frequent bridges, tunnels and elevated structures, may justify a far greater cost per tie than would be justified on many of our great western systems, and this, too, independently of the actual first cost of the tie itself. Mr. Kummer.

Mr. Montfort's interesting discussion throws some strong light upon the necessity of thorough sterilization. He cites instances of piles treated with creosote oil, and with creosote and resin mixed, in which heart rot was found to exist in a large proportion of the piles, especially in those treated with the resin mixture. There is no doubt that this heart rot could be prevented by thorough sterilization of the piles before treatment, and the writer is glad to note this strong evidence of the necessity of sterilization. It seems probable that the most perfect method for the treatment of piles would be with creosote oil alone, after thorough sterilization, the surface of the piles being subsequently subjected to a resin and lime treatment to form an insoluble outer covering to retain the dead oil. The conditions for resistance to the teredo and to ordinary decay are, of course, quite different.

The writer was not aware of Mr. Putnam's experiments with resin, creosote oil and petroleum, and certainly had no desire to claim any originality in the presentation of the creosote-resin process to which he was not justly entitled.

With regard to the zinc-tannin process, an interesting question arises. The impregnating solution, which is 90% water, is immediately followed by the tannin treatment, which latter, it is claimed, completely seals the pores against the entrance of moisture from the outside. If this be true, and moisture cannot enter from the outside, how can the moisture inside the timber escape, as is claimed it does? If, on the other hand, the pores are open to the escape of this large percentage of water from within, would they not be equally open to the entrance of water from the outside, and the consequent dissipation of the injected chemical?

Mr. Skinner's comments doubtless arise from a slight misapprehension. In saying that it is practically out of the question to force an antiseptic fluid entirely throughout large sticks of timber, this of course means "commercially out of the question." Doubtless it can be done, at great expense and loss of time.

With reference to the withdrawal of all the volatile oils, the process is designed especially to prevent this. The oils are valuable in the wood. Sterilizing alone would not preserve timber, because germs would enter from without. Complete impregnation is too expensive.

The writer regards the estimate of 10 years as the average life of un-

Mr. Kummer. treated yellow pine ties as too high. This might be the average life on elevated structures, but in the ground the records from several large systems indicate that the average life is about 7 years or less.

Mr. Chanute, in a paper before the Western Society of Engineers, recently said that he had been trying for years to find a solvent for metallic salts, such as zinc chloride, which would be oily in its nature, so as to prevent the preservative fluid from washing out, and that such a solvent would make a perfect process; but he had—at least at that time—never found it, and they are still generally using water in connection with the salts. The admixture of resin, creosote and formaldehyde gives an admirable combination of the antiseptic, waterproof, hardening and spike-holding qualities, in the writer's opinion, not equalled by the German combination of creosote oil and chloride of zinc.

This process, mentioned by Mr. Goldmark, is attracting a great deal of attention. The writer is convinced that it is a distinct advance over Burnettizing alone. How it would act if applied to yellow pine timber has probably not yet been determined, but Mr. Chanute is, the writer understands, investigating that question now. It would seem that its weak point might be in its application, particularly, to the inferior grades of timber, which cannot be used without a tie-plate, and which have low spike-holding qualities. It certainly could not harden the timber, and this the creosote-resin process does to a very great degree. In this connection, it is interesting to note that from 50 to 60% of the renewals on certain of our eastern lines with heavy traffic, come from crushing or failure of spikes to hold, and not from decay. For this reason inferior grades of timber, no matter how well preserved against decay, would not last longer than if absolutely untreated, unless the treatment were such as to very materially harden the wood and increase its spike-holding qualities. If a treatment which does this be used, and in addition be applied to timber such as yellow pine, which is in itself a hard and resisting timber, the results should so resist the effects of crushing and spike pulling that the preservative part of the treatment could come into play.

It is the writer's opinion that the creosote-resin process, with its positive waterproof qualities, its greatly increased hardness and spike-holding qualities, its thorough and complete sterilization, and the nature of the antiseptic used, is one of the best methods for the treatment of timber that has yet been advanced. The greatest argument against its general use would seem to be one of cost; but even that question is yearly becoming less important in those sections of the country where railroad travel is heaviest and traffic most congested.

Mr. Valentine's discussion is of great interest as indicating favorable results with treated wooden paving blocks, more favorable than those secured in many other instances in this country.

The patents referred to as issued to Mr. Putnam on a combination of creosote and resin, and which it is asserted Mr. Putnam declared a failure, must have differed very materially from that now used by the works at Perth Amboy, since the latter process has been granted full patents by the United States patent office. Whatever the process tried by Mr. Putnam was, it would be instructive to know the nature of the experiments which caused him to declare his process a failure. The indications are that they referred only to marine work, as a protection against the teredo, as mentioneed by Mr. Curtis in his discussion. Mr. Kummer.

Mr. Valentine gives no reason why Mr. Putnam abandoned his compounds. It may have been due to inability to obtain proper penetration or possibly to the sticky nature of the product, such as is obtained when using creosote and resin alone. The attention of the writer has been called to a letter from the International Creosoting and Construction Company of Beaumont, Texas, in which the statement is made that the piles treated at Lake Pontchartrain by Mr. Putnam were "thoroughly saturated with resin oil, with a mixture of resin sufficient to form a body." Apparently, no creosote oil at all was used in this case. Of course, no claim is made that resin or resin oil alone will act as an efficient preservative.

Judging from the concluding paragraph of Mr. Valentine's discussion, he seems to infer that the object of the creo-resinate process is to cheapen the cost of treatment. This, of course, is a misconception of its purpose. The new process is a modified and improved creosoting process, yielding, it is claimed, a better and more durable product without increasing the cost. At present, the process is recommended principally for paving blocks and railroad timber, the question of its efficiency for use in piles being still unsettled, as already stated.

It appears that Mr. Putnam's treatment was confined entirely to piling. The results of his experiments, therefore, good or bad, even if his process was of a similar nature to that described in the paper, can have no weight in forming an opinion of its value for the purpose of preserving timber against decay.

The writer has made a careful examination of the patents issued to Mr. Joseph W. Putnam for a wood-preserving compound consisting of a mixture of resin, creosote and resin oil, and a mixture of resin, petroleum and resin oil. Mr. Valentine states that this process was abandoned. There are many reasons why such may have been the case, and still not throw the least discredit upon another process using apparently the same mixture. The mixture of resin and petroleum is undoubtedly inferior to that of resin and creosote, and may therefore be left out of consideration.

The patent papers say: "No particular proportions of the resin and oils need be observed in preparing the compound except that the

Mr. Kummer. quantity of oil or oils should be sufficiently in excess of the resin to facilitate its thorough solution." There is no statement anywhere giving the absolute amount of creosote used. This may have been reduced so low as to make the preservative effect nil. According to the requirements of the patent, none at all need be used, for the resin oil alone would be sufficient to facilitate the thorough solution of the resin. As a matter of fact, the writer can discover no reason for using resin oil at all except as a substitute for creosote oil. The latter will dissolve resin very effectually, and is a far more powerful antiseptic; consequently the resin oil can add neither to the solvent power of the mixture nor to its preservative qualities. Excessive use of this resin oil may be one explanation of the failure of the process.

Lacking the details of the treatment and experiments actually made, it is impossible to say whether the process was ever properly tested. It is well known that there are on record many cases of the total failure of the creosoting process. These, on careful examination, have been proven to be due entirely to improper application of the process. No one at the present time would throw discredit upon creosote as a preservative on this account.

Mr. Putnam, in his patent specification, does not give any method of applying his mixture. He states: "The compound may be applied to the timber in any suitable or well-known way." The supposition that the wood was saturated to the center may be excluded as not being practicable. consequently, the question of sterilization becomes important. There is no record, either in the patent papers or in the description of the experiments, to show that the wood was thoroughly sterilized, or even that this was taken into consideration. In fact, Mr. Putnam's own statement of the object of his process, *i. e.*, to make the wood more durable and better able to resist the attacks of insects and marine animals and the deteriorating influences of air and moisture, would lead one to suppose that he ignored entirely the great danger of germs of decay existing in the interior of the wood itself.

Finally, the writer will again call attention to the fact that Mr. Putnam's mixture would leave the timber with a very sticky surface, making it almost impossible to handle in bulk. Any or all of these causes may have contributed to his final abandonment of the process.

The statements contained in Mr. Valentine's discussion relative to paving blocks laid in Galveston are very encouraging. It would be a decided mistake to suppose that the claims made for the creo-resinate process conflict with these in the least. On the contrary, they are in perfect accordance with the prevailing opinion that creosote is an excellent preservative—the best known at the present time for this class of work. The creo-resinate process is put forward as an improvement on ordinary creosoting, yielding a product which it is claimed has cer-

tain advantageous physical properties, such as greater resistance to crushing, more elasticity, and waterproof qualities not obtainable with creosote alone, and at the same time retaining its power as a preservative. It is far from the writer's desire to throw any discredit whatever upon creosote as an antiseptic. Mr. Kummer.

With regard to the treatment of piles. discussed by Mr. Valentine, no claims have been made that the creosote-resin mixture will resist the teredo. Whether it will or will not do so is an open question until proper experiments can be made to decide this point.